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A REVIEW OF MTO CONCRETE COMPRESSIVE STRENGTH DATA FOR 1987

MATERIALS INFORMATION
ENGINEERING MATERIALS OFFICE

A REVIEW OF M.T.O. CONCRETE COMPRESSIVE STRENGTH DATA FOR 1987

BY

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CONCRETE SECTION

MARCH 1988

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INTRODUCTION

The Concrete Section of the Engineering Materials Office receives copies of the 28-day compressive strength tests from throughout the Province. These results are placed in a microcomputer for the purpose of reviewing the results and to provide contract, regional and provincial summaries. Concrete placed on Ministry contracts must meet the requirements of OPSS 1350 in the Ontario Provincial Standard Specifications. One of the requirements of acceptance is based on the results of 28-day compressive strength tests as specified in Section 1350.08.01.05 of the specifications.

The purpose of this report is to provide a summary and review of 28-day compressive strength test results from the 1987 contracts throughout Ontario involving concrete work. The summary includes test results of all concrete classes from 15 MPa to 35 MPa including latex modified concrete. Not included in the report are results on concrete placed on maintenance and municipal contracts or tremie concrete. Only the test results from concrete placed in 1987 are included in the report.

RESULTS

A test is defined as the average of two standard 150 mm x 300 mm cylinders as stated in OPSS 1350. For this report the term "pass" and "fail" have been used. The "pass" term indicates that the results of a single 28-day compressive test (average of 2 standard cylinders) is greater than or equal to the specified strength. The "fail" term indicates that the results of a single 28-day compressive strength test is less than the specified strength. Table A shows the total number of tests performed in each of the five regions as well as the percentage of tests that passed and failed. In Table B the tests in each region are broken down by concrete with no slag cement, concrete containing slag cement and latex modified concrete.

Figures 1 - 7 provide a graphical summary of test results by concrete class and type. The figures show the mean and the standard deviation of all test results by contract for each concrete class in the five regions. Actual contract numbers in each region have been replaced with a series of numbers beginning at 1. Contracts that contain less than two test results for a given concrete class were not shown in these figures. Appendix A contains the statistics in all test results throughout the Province in tabular form.

Figure 1 summarizes test results for 20 MPa class concrete containing no slag cement. Good compressive strengths were achieved with this class of concrete. 293 tests were carried out in all regions and only one test in Central Region and Southwestern Region failed to meet the specified strength.

Figure 2 contains the summary of test results for 20 MPa class concrete containing slag cement. No difficulties were encountered in the two regions (Central and Eastern) that used this class of concrete.

Figure 3 presents the test results for 25 MPa class concrete containing no slag cement. All regions experienced some difficulty with this class of concrete. In Central Region 2 tests out of 101 failed to meet the specified strength. Southwestern Region had 1 test fail out of 88 tests while Eastern Region had 8 failures out of 49 tests. In Northern Region 1 test failed to meet the required strength out of 10 tests. Northern Region had 3 failures out of 78 tests.

TABLE A SUMMARY OF TESTS BY REGION

REGION	NUMBER OF TESTS	% PASS	% FAIL
CENTRAL	1542	92.7	7.3
SOUTH-WESTERN	416	96.9	3.1
EASTERN	636	93.1	6.9
NORTH-WESTERN	277	95.3	4.7
NORTHERN	380	94.5	5.5
ALL REGIONS	3251	93.8	6.2

TABLE B SUMMARY OF TESTS BY REGION (NON-SLAG CEMENT,SLAG CEMENT,LATEX MODIFIED CONCRETE)

REGION	15 MPa		15 MPa SLAG		20 MPa		20 MPa SLAG		25 MPa		25 MPa SLAG	
	#TESTS	% PASS	#TESTS	% PASS	#TESTS	% PASS	#TESTS	% PASS	#TESTS	% PASS	#TESTS	% PASS
CENTRAL REGION	-	-	1	100	75	98.7	60	100	101	98.0	99	94.9
SOUTH-WESTERN REGION	-	-	-	-	96	99.0	-	-	88	98.9	-	-
EASTERN REGION	-	-	-	-	61	100	9	100	49	83.7	29	100
NORTH-WESTERN REGION	1	100	-	-	29	100	-	-	10	90.0	-	-
NORTHERN REGION	-	-	-	-	30	100	-	-	78	96.2	-	-
ALL REGIONS	1	100	1	100	293	99.3	69	100	326	95.4	128	96.1

REGION	30 MPa		30 MPa SLAG		30 MPa LATEX		35 MPa		35 MPa SLAG	
	#TESTS	% PASS	#TESTS	% PASS	#TESTS	% PASS	#TESTS	% PASS	#TESTS	% PASS
CENTRAL REGION	404	92.8	468	90.0	36	88.9	65	93.8	233	91.4
SOUTH-WESTERN REGION	206	95.6	-	-	-	-	24	91.7	-	-
EASTERN REGION	447	92.4	32	93.8	9	100	-	-	-	-
NORTH-WESTERN REGION	223	94.6	-	-	14	100.0	-	-		
NORTHERN REGION	242	93.0	-	-	-	-	30	96.7	-	-
ALL REGIONS	1522	93.4	500	90.2	59	93.2	119	95.0	233	91.4

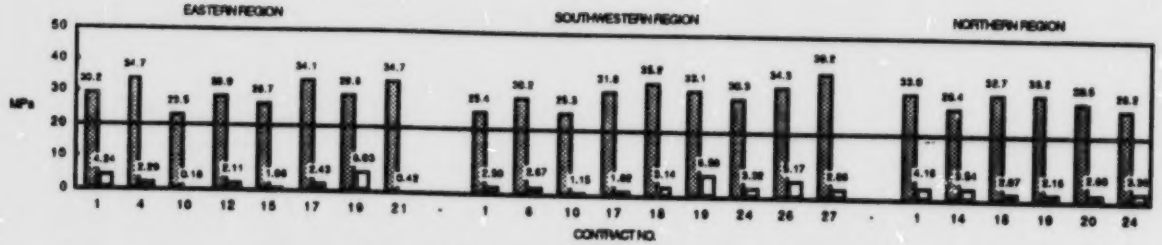


FIGURE 1 SUMMARY OF TESTS BY CONTRACT - 20 MPa NON-SLAG CEMENY

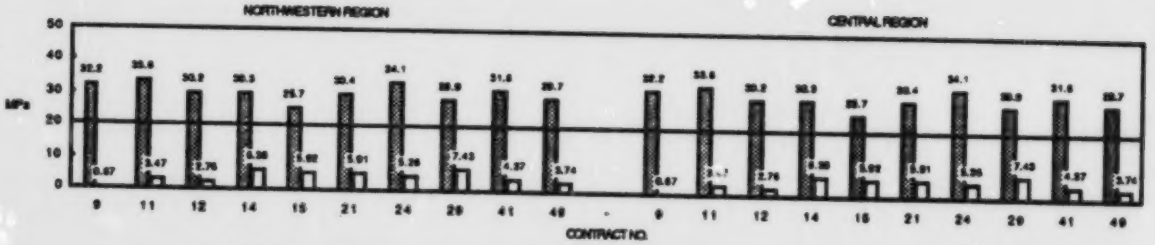


FIGURE 1 SUMMARY OF TESTS BY CONTRACT - 20 MPa NON-SLAG CEMENT

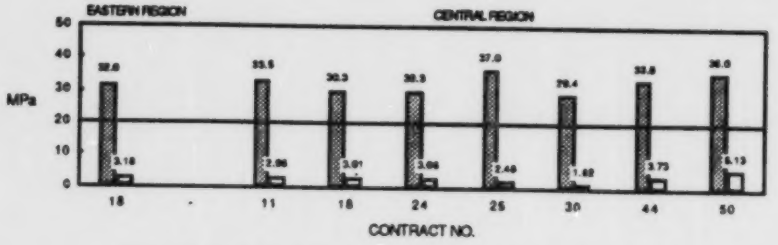


FIGURE 2 SUMMARY OF TESTS BY CONTRACT - 20 MPa SLAG CEMENT

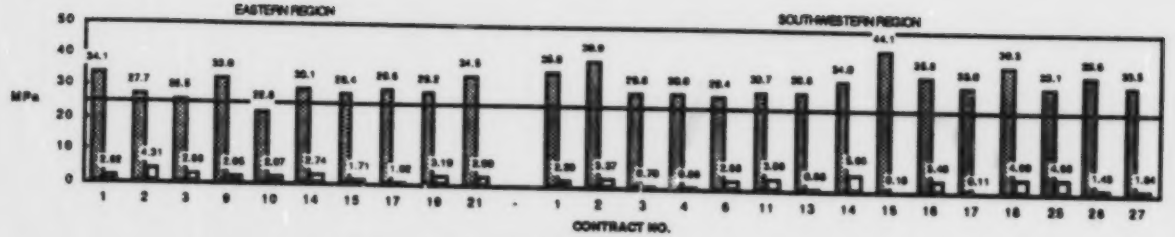


FIGURE 3 SUMMARY OF TESTS BY CONTRACT - 25 MPa NON-SLAG CEMENT

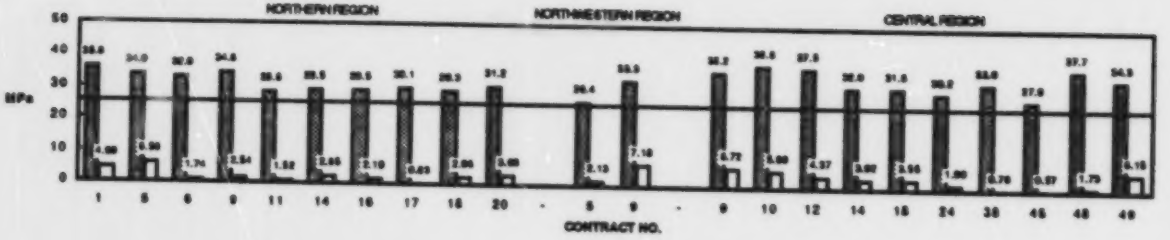


FIGURE 3 SUMMARY OF TESTS BY CONTRACT - 25 MPa NON-SLAG CEMENT

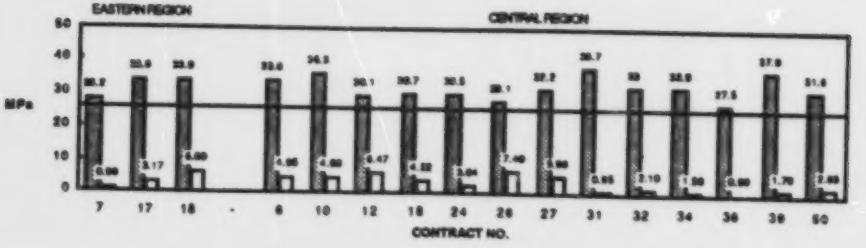


FIGURE 4 SUMMARY OF TESTS BY CONTRACT - 25 MPa SLAG CEMENT

LEGEND

The test results for 25 MPa class concrete containing slag cement are present in Figure 4. Only Central Region and Eastern Region used this class of concrete. Eastern Region had no problems with this class of concrete while in Central Region 5 tests out of 99 tests failed to meet the specified strength.

Figure 5 contains the test results for 30 MPa class concrete containing no slag cement. All regions experienced difficulties with this class of concrete. Out of 1,522 tests, 6.6 percent failed to meet the required specified strength.

Figure 6 presents the test results for 30 MPa class concrete containing slag cement and for latex modified concrete. Only Central and Eastern Regions used the 30 MPa class concrete with slag cement. Both regions experienced difficulties with this class of concrete. 49 tests out of 500 tests failed to meet the required strength. Latex modified concrete was used in Central, Eastern and Northwestern Regions. In Central Region 4 tests failed to meet the specified strength out of 36 tests. The other regions had no problems with this type of concrete.

Figure 7 summarizes test results for 35 MPa class concrete with and without slag cement. The three regions (Central, Southwestern and Northern) that used the 35 MPa class concrete without slag experienced difficulties. In Central Region 4 tests out of 65 tests failed to meet the required strength. Southwestern Region had 2 test failures out of a total of 24 tests while Northern Region had 1 test fail the specified strength requirement out of 30 tests. Central Region was the only region to use 35 MPa class concrete containing slag cement. Out of 233 tests, 20 tests failed to meet the required strength.

SUMMARY

1. Good compressive strengths were achieved with the 15 MPa and 20 MPa class concrete with or without slag cement.

2. All regions experienced low compressive strengths with 25 MPa, 30 MPa and 35 MPa class concrete with or without slag cement. The only exception was Eastern Region where no difficulties were encountered with the 25 MPa class concrete with slag cement.

3. Good compressive strengths were achieved with latex modified concrete in Eastern and Northwestern Regions. Central Region experienced low compressive strength with the latex modified concrete.

4. 3,251 tests were carried out in 1987 of which 93.8 percent were greater or equal to the required strength. In 1986, 3,072 tests were carried out, of which 93.3 percent of the tests met the required specified strength. 91.3 percent out of 3,095 tests in 1985 met the required strength.

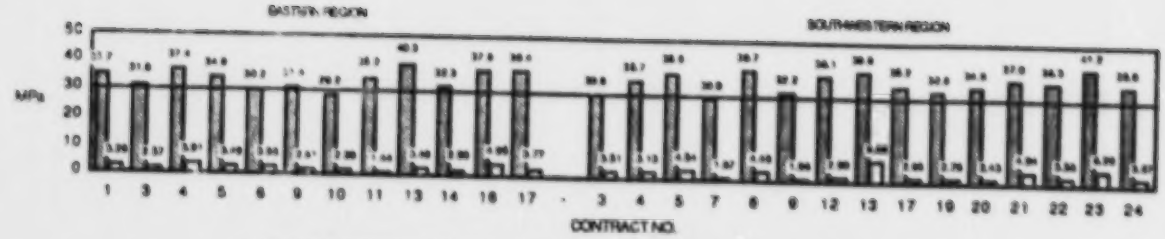


FIGURE 5 SUMMARY OF TESTS BY CONTRACT - 30 MPa NON-SLAG CEMENT

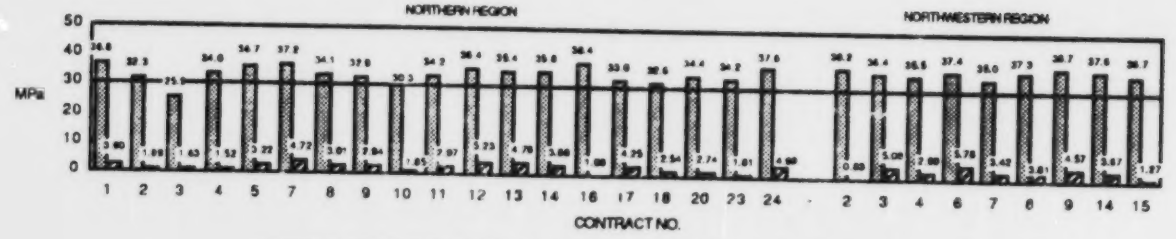
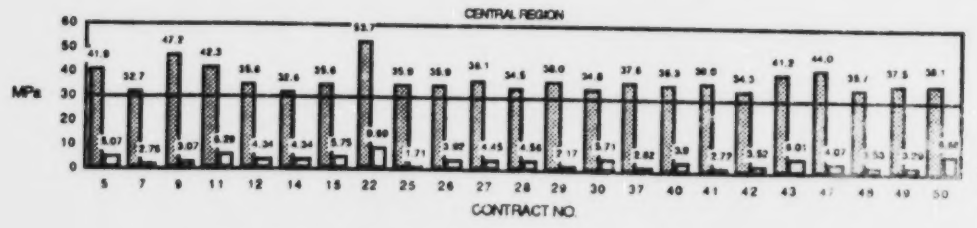
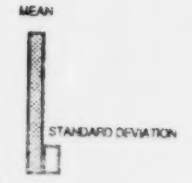


FIGURE 5 SUMMARY OF TESTS BY CONTRACT - 30 MPa NON-SLAG CEMENT





LEGEND

FIGURE 5 SUMMARY OF TESTS BY CONTRACT - 30 MPa NON-SLAG CEMENT

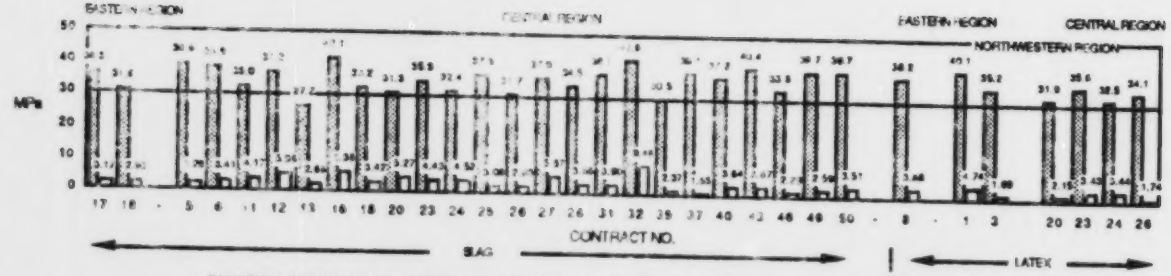
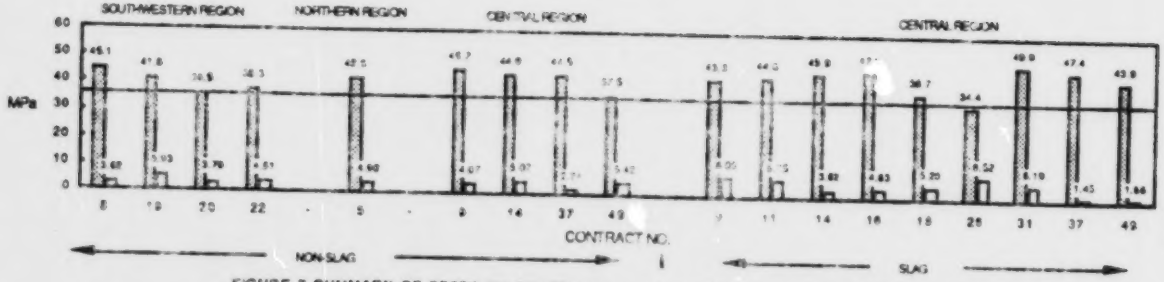


FIGURE 6 SUMMARY OF TESTS BY CONTRACT - 30 MPa SLAG CEMENT AND LATEX MODIFIED CONCRETE



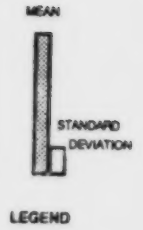


FIGURE 7 SUMMARY OF TESTS BY CONTRACT - 35 MPa NON-SLAG CEMENT AND SLAG CEMENT

APPENDIX A

CENTRAL REGION

CON-TRACT	15 MPa SLAG			20 MPa			20 MPa SLAG			25 MPa			25 MPa SLAG			30MPa			30 MPa SLAG			30 MPa LATEX MOD.			35 MPa			35 MPa SLAG		
	# TESTS	MEAN	ST.DEV	# TESTS	MEAN	ST.DEV	# TESTS	MEAN	ST.DEV	# TESTS	MEAN	ST.DEV	# TESTS	MEAN	ST.DEV	# TESTS	MEAN	ST.DEV	# TESTS	MEAN	ST.DEV	# TESTS	MEAN	ST.DEV	# TESTS	MEAN	ST.DEV	# TESTS	MEAN	ST.DEV
1										1	33.5	-																		
2																														
3																1	33.5	-												
4				1	36.5	-													1	40.7	-									
5																5	41.9	5.07	7	39.5	3.28				1	41.8	-	1	50.5	-
6													4	33.8	4.95				15	38.8	3.41									
7																2	32.7	2.78												
8																1	32.3	-												
9				2	32.2	0.67				15	36.2	6.72				4	47.2	3.07												
10				1	37.2	-	1	33.2	-	7	38.6	5.69	27	36.3	4.8				1	29.0					21	46.2	4.07	8	43.3	6.06
11				5	33.6	3.47	7	33.5	2.96							3	42.3	6.29	16	33.3	4.17									
12				3	30.2	2.76				5	37.5	4.37	2	30.1	6.47	24	35.8	4.34	26	37.2	5.96				1	33.3	-	34	44.0	6.75
13																			4	27.2	2.66									
14				11	30.3	6.36				17	32.0	3.92				24	32.6	4.34												
15				3	25.7	5.92	1	31.7	-							15	35.6	5.75							28	44.0	5.07	3	45.8	3.82
16																														
17																			5	42.1	6.38									
18							16	30.3	3.01				1	36.6	-													104	47.0	4.03
19										21	31.6	3.55	17	30.7	4.22				86	33.2	3.42									
20										1	29.3	-																28	38.7	5.26
21				13	30.4	5.91													10	31.3	5.27	6	31.9	2.15						
22										1	31.6	-				1	31.0	-												
23										1	43.3	-				2	53.7	9.69												
24																			67	35.3	4.43	16	35.6	3.43						
25				5	34.1	5.26	4	30.3	3.06	3	30.2	1.90	16	30.5	3.04	1	42.1		26	32.4	4.52	10	32.5	3.44						
26				1	35.7	-	3	37.0	2.48	1	37.2	-				10	35.9	1.71	18	37.5	3.08									
27													5	28.1	7.4	4	38.7	3.92	7	31.7	2.83	4	34.1	1.74						
28													10	32.2	5.98	15	38.1	4.45	54	37.0	5.57				1	42.6	-	19	34.4	8.52
29				8	28.9	7.43	1	31.8	-							38	34.8	4.56	45	34.5	3.58									
30				1	23.8	-	5	29.4	1.62							15	38.0	2.17												
31																14	34.8	5.71												
32													2	38.7	0.95				9	38.1	3.90									
33													3	33.0	2.1				3	42.6	9.46							26	49.9	6.19
34																1	33.2	-												
35							1	30.4	-	1	34.5	-	4	32.9	1.59																
36																			16	30.5	2.37									
37													4	27.5	0.9															
38																67	37.6	2.82	4	39.1	1.85				5	44.5	2.24	2	47.4	1.45
39										2	33.0	0.78																		
40													2	37.9	1.7															
41				13	31.6	4.37										46	36.3	3.90	3	37.2	3.64									
42																2	38.0	2.72												
43																39	34.3	3.52												
44																8	41.2	6.01	19	40.4	3.87									
45							18	33.8	3.73										1	31.4	-									
46										3	27.9	0.57																		
47																			4	33.6	2.29									
48																3	44.0	4.07												
49				7	28.7	3.74				2	37.7	1.73				25	36.7	3.53												
50	1	33.2	-	1	33.1	-	3	38.0	6.13	20	34.3	6.15	2	31.6	2.83	27	37.5	3.29	10	39.7	2.59				8	37.5	5.42	8	43.9	1.66
																7	38.1	6.66	9	39.7	3.51									

SUMMARY OF 28-DAY COMPRESSIVE STRENGTH TEST RESULTS

SOUTHWESTERN REGION

CON-	20 MPa			25 MPa			30 MPa			35 MPa		
TRACT	# TESTS	MEAN	ST.DEV	# TESTS	MEAN	ST.DEV	# TESTS	MEAN	ST.DEV	# TESTS	MEAN	ST.DEV
1	9	25.4	2.50	4	35.8	2.20						
2				6	39.9	3.37						
3				3	29.8	0.70	4	30.8	3.51			
4				2	30.0	0.88	4	35.7	3.13			
5							4	38.6	4.54			
6	23	30.2	2.67	4	29.4	2.88						
7				1	20.6	-	2	30.0	1.87			
8							55	39.7	4.46	7	45.1	3.62
9							5	32.2	1.96			
10	4	25.3	1.15									
11				7	30.7	3.88						
12							5	38.1	2.90			
13				2	30.6	0.88	10	39.8	8.68			
14				2	34.0	5.66						
15				2	44.1	0.18						
16				34	35.8	3.48						
17	3	31.8	1.82	2	33.0	0.11	13	35.2	2.66			
18	31	35.2	3.14	5	39.3	4.69						
19	8	33.1	6.58	1	33.5	-	2	32.8	2.76	8	41.8	5.93
20							10	34.9	2.43	3	36.5	3.79
21							27	37.0	4.94			
22							20	36.3	3.58	6	38.3	4.61
23							9	41.2	6.28			
24	6	30.3	3.32				35	35.8	3.67			
25	1	36.1	-	5	33.1	4.68	1	38.2	-			
26	11	34.3	5.17	4	36.6	1.43						
27	2	39.2	2.86	4	33.5	1.84						
28												

SUMMARY OF 28-DAY COMPRESSIVE STRENGTH TEST RESULTS

EASTERN REGION

CON-TRACT	20 MPa			20 MPa SLAG			25 MPa			25 MPa SLAG			30 MPa			30 MPa SLAG			30 MPa LATEX MOD.		
	# TESTS	MEAN	ST.DEV	# TESTS	MEAN	ST.DEV	# TESTS	MEAN	ST.DEV	# TESTS	MEAN	ST.DEV	# TESTS	MEAN	ST.DEV	# TESTS	MEAN	ST.DEV	# TESTS	MEAN	ST.DEV
1	7	30.2	4.24				7	34.1	2.62				121	35.7	3.28						
2							2	27.7	4.31												
3							3	26.5	2.88				14	31.8	2.57						
4	6	34.7	2.29				1	33.9	-				158	37.4	3.91						
5													17	34.8	3.49						
6																					
7				1	31.2	-				2	28.2	0.99	21	30.2	3.66						
8																					
9																			9	38.2	3.88
10	2	23.5	0.18				2	33.0	2.05				33	31.4	2.61						
11							4	22.8	2.07				6	29.2	2.28						
12	17	28.9	2.11										4	35.2	1.44						
13																					
14													21	40.3	3.48						
15	4	26.7	1.06				3	30.1	2.74				9	32.3	2.93						
16							7	28.4	1.71												
17	18	34.1	2.43	1	29.5	-	4	29.6	1.02	4	33.8	3.17	15	37.8	4.95						
18				7	32.0	3.18				23	33.9	6.00	28	38.4	3.77	24	36.3	3.17			
19	4	29.6	6.03				12	29.2	3.19							7	31.6	2.60			
20																					
21	2	34.7	0.42				4	34.5	2.90							1	40.1	-			

NORTHWESTERN REGION

CON-TRACT	15MPa			20 MPa			25 MPa			30 MPa			30 MPa LATEX MOD.		
	#TESTS	MEAN	ST. DEV.	# TESTS	MEAN	ST.DEV	# TESTS	MEAN	ST.DEV	# TESTS	MEAN	ST.DEV	# TESTS	MEAN	ST.DEV
1													10	40.1	4.74
2										3	38.2	0.83			
3										56	36.4	5.08	4	35.2	1.89
4				7	33.1	5.01				15	35.5	2.90			
5				2	25.8	2.58	5	26.4	2.13						
6				10	36.2	4.97				6	37.4	5.78			
7										50	35.0	3.42			
8										7	37.3	3.81			
9	1	19.4	-				5	33.3	7.18	77	38.7	4.57			
10				3	38.0	5.40									
11				1	34.6	-									
12										1	36.8	-			
13				4	34.0	5.38									
14										6	37.6	3.67			
15				2	32.5	3.85				2	36.7	1.27			

SUMMARY OF 28-DAY COMPRESSIVE STRENGTH TEST RESULTS

NORTHERN REGION

CON-TRACT	20 MPa			25 MPa			30 MPa			35 MPa		
	# TESTS	MEAN	ST.DEV	# TESTS	MEAN	ST.DEV	# TESTS	MEAN	ST.DEV	# TESTS	MEAN	ST.DEV
1	8	33.0	4.16	4	35.8	4.99	53	36.8	3.60			
2				1	33.4	-	6	32.3	1.89			
3							2	25.9	1.63			
4							5	34.0	1.52	1	32.6	-
5				5	34.0	6.58	17	36.7	3.22	29	42.6	4.60
6	1	33.0	-	4	32.9	1.74	1	31.0	-			
7	1	31.3	-				16	37.2	4.72			
8	1	33.7	-	1	36.9	-	16	34.1	3.01			
9	1	28.1		3	34.6	2.54	12	32.9	2.94			
10							4	30.3	1.85			
11	1	29.3	-	2	28.8	1.52	19	34.2	2.97			
12							2	36.4	5.23			
13	1	26.9	-	1	33.0	-	19	35.4	4.78			
14	3	28.4	3.54	3	29.5	2.65	25	35.8	3.88			
15				1	28.7	-						
16				31	29.5	2.19	3	38.4	1.08			
17				3	30.1	0.83	3	33.0	4.25			
18	6	32.7	2.07	10	29.3	2.96	4	32.6	2.54			
19	2	33.2	2.16	1	29.8	-	1	28.6	-			
20	3	30.5	2.68	7	31.2	3.63	26	34.4	2.74			
21				1	36.8	-						
22							1	37.8	-			
23							4	34.2	1.81			
24	2	28.2	3.36				3	37.6	4.99			

SUMMARY OF 28-DAY COMPRESSIVE STRENGTH TEST RESULTS